Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 4, Issue 4; July-September, 2017, pp. 318-320

http://www.krishisanskriti.org/Publication.html

Fibre Reinforced Polymer– A Noble Piling Material

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Abstract—*Foundations are provided to transfer loads from the structure to the strata. Depending upon the requirement shallow and deep foundations was used on site. Application of pile or deep foundations was performed when the use of shallow foundation does not provide sufficient bearing capacity or large settlements are expected. Pile foundations have been used extensively for both inland and offshore. Various traditional materials such as timber, concrete, steel were used since long time but with the advancement of technology noble material such as fibre reinforced polymer (FRP) is the future in this category. Traditional pile materials suffer from limited lifespan especially in harsh environments where the corrosion of steel and degradation of concrete and timber becomes a significant issue. In addition, the maintenance associated with the repair and retrofit of such structures can incur significant costs. FRP material presents favourable property, such as high specific strength, lightweight, durability, resistance to corrosion and weathering effect. To implement FRP materials in piling industry few ongoing projects were implemented, however they have yet to been accepted as a standard piling material. Lack of design guidelines, pilot projects demonstrating the viability of the material from the technical and economical point of view and limited engineering data on FRP-soil interface behaviour has been identified as factors preventing commercial use of composite piles. Due to lack of data on behaviour and properties related with FRP as pile material makes it difficult to use on industrial level. Further work is needed to understand and accept it as construction material. Full scale pile load test data will help for comparison to capacity estimation calculated from pile driving analysis. These tests are needed in order to characterize pile deformation caused by soil interaction. With more research on the material, it will open the new doors for construction practices worldwide.*

Keywords*: Fibre Reinforced Polymer, Pile, FRP-soil interface.*

1. INTRODUCTION

Construction of foundations especially deep foundation with widely used traditional material such as steel, concrete, timber had faced significant amount of deterioration with the passage of time. To cater this specific problem, FRP piles or piles of traditional materials protected with FRP are found to provide good results as compared to traditional materials. Most of the piles constructed with timber, concrete and steel experience shorter life spans due to corrosion, degradation and weathering effect. [1] These harmful effects could be avoided by treating the piles from elemental degradation by painting the timber and steel with heavy coating etc. but they are very costlier and still do not guarantee for a very long duration.

Acceptance of FRP or composite piles will increase when more engineering data will be available in support of their application and utility. Research works are being carried out around the world to understand the behaviour of these materials such as shear strength, soil-pile interface behaviour, material property.

2. PILING MATERIAL

Timber Piles

Due to ease in availability, timber piles are the oldest type of foundation that has been used to support structural loads. Its high strength to weight makes it an ideal material for piling. Several types of timber such as softwoods and hardwoods are used in piling. Timber piles in marine structures are prone to damage, due to moisture contact. The driving end of timber piles should be protected by steel or cast iron shoe to avoided damage as it comes in contact with the strata. Similarly a driving cap may be installed on the driving end to protect the butt from hammering effects.

Concrete Piles

Concrete is the most common and widely accepted traditional construction material. Concrete piles can be classified into following three categories namely precast concrete piles, cast in place concrete piles and composite concrete piles.[4] Concrete piles could be adjusted as per the desired length and it is suitable for wide range of loads. Chemical deterioration due to contaminated groundwater from manufacturing plant wastes and leaky sewers or seawater, damage due to freezing and thawing, damage due to handling and driving stresses and damage due to concrete material defects such as cavities and soil pockets are the major disadvantages of this material. The most destructive chemicals for reinforced concrete piles are sodium and calcium chlorides. Their penetration into the concrete causes electrochemical effect and leads to corrosion and causes heavy damage. Concrete piles in seawater are susceptible to sulphate attack.

Steel Piles

Steel piles are also available in good quantity and their properties such as lightweight, load carrying capacity, length adjustment as per requirement makes it popular in the construction industry. Various types of steel piles are used in practice such as pipe piles, H-section piles, square section piles and tapered tubes. Steel pipe piles can either be driven open ended or closed open ended. Steel is susceptible to deterioration during their service life due to corrosion, especially in industrial and marine environments. Corrosion of steel piles can be reduced by coatings containing heavy metals but these metals are harmful to the environment and the process utilizes significant money and labor.

FRP Composite Piles

Composite piles are lightweight, easy to handle and shows insignificant deterioration when exposed to harsh conditions. These following types of materials are available in market- plastic encased steel pipe core piles, reinforced plastic piles, FRP confined concrete piles, fibre glass pultruded pipe piles and plastic lumber piles as shown in Fig. 1.

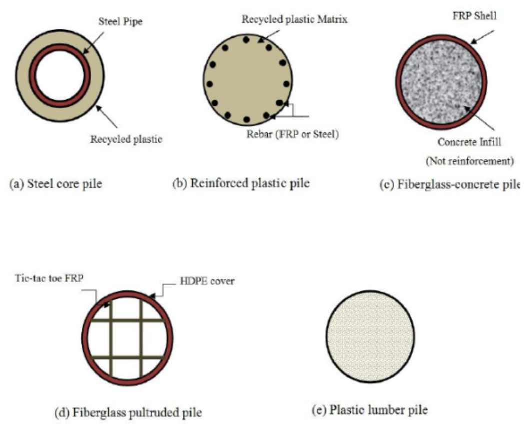

Fig. 1: Common types of composite piles. [5]

FRP tube confined concrete piles were used in some studies that involved FRP composite piles such as Carbon Fiber Reinforced Polymer (CFRP) and Glass Fiber Reinforced Polymer (GFRP) and showed acceptable results. Ultimate pile resistance (compressive) of FRP piles in small scale test on model piles for the same study was reported to be 40% higher than the steel pile used in the test, also skin frictional resistance was reported to be 30% higher. [6]

3. EFFECT OF MATERIAL SELECTION ON PILE PERFORMANCE

Selection of pile material is very important for piling. Every material has different engineering behaviour and depending upon that shows variation in results. Below mentioned Fig. depicts the results obtained by Velez [7] for five pile load tests showing lateral resistance and pile displacement ration.

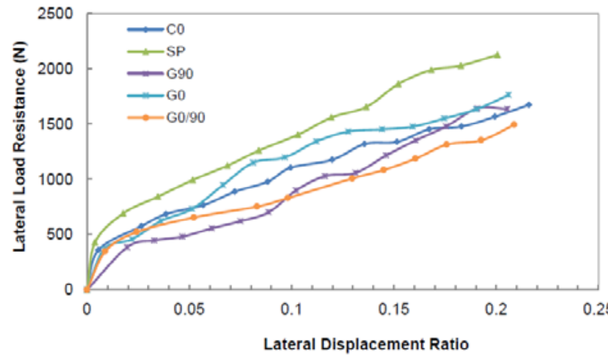

Fig. 2: Lateral pile resistance v/s pile displacement ratio [7]

The steel pile tested in the above case reported an increase in lateral resistance up to 28 percent higher at failure as compared to the used FRP materials. In above case FRP material used were carbon and glass fibre reinforced polymer.

Variation in selected material for piling shows different results due to the significant changes in soil-pile material interface. The large difference in interface roughness between concrete, steel and FRP materials was found mainly due to the interface texture formed by the FRP woven fabrics and the epoxy casting during the manufacturing process.

Table-1 shows a summary of lateral capacity for the different piles and their corresponding flexural stiffness estimated in the same study. [7] It was observed that piles at peak lateral displacement ratio were only approximately under 20-30 percent of their ultimate flexural capacity well below structural failure.

Table 1: Lateral capacity and properties of FRP and steel piles [7]

Pile	Lateral capacity at 6.25mm (N)	Pile stiffness at 2000N load (kN-m^2)	Pile stiffness at failure (kN-m^2)	Lateral resistance ratio to steel
C 0	880	6.4	6.8	80
C 90	N/A	N/M	N/M	86.4
C 0/90	650	N/M	N/M	59
G 0	950	9.7	11.4	86.6
G 90	580	N/M	N/M	52
SP	1100	25.75	25.75	

N/M- Not measured in this study.

4. ADVANTAGES AND DISADVANTAGES

Higher strength, corrosive resistance, immunity to decay and deterioration against marine environment, durability are the advantages of composite piles over the traditional material piles. [2] The positive effect of these advantages is reduction in transportation and installation cost due to their light weight and requirement of reduced maintenance as compared to the traditional materials. In most of the cases composite materials are easily recyclable which has immediate positive impact on the environment. Being new to civil engineering industry, manufacturers have yet to find cheap production methods for commercial application. This disadvantage makes composites more expensive as compared to traditional material. Being advantageous with its properties still its acceptance is low. Table 2 describes an example of comparison of typical ranges of FRP composite characteristics with those of traditional steel material.

Table 2: Rating for FRP v/s Steel [3]

Parameter	Rating	
	FRP	Steel
Stiffness	4-5	4
Weight	5	2
Corrosion Resistance	4-5	3
Ease of field construction	5	3-4
Ease of repair	4-5	3-5
Fire	3-5	4
Transportation	5	3
Toughness	4	4
Acceptance	2-3	5

Note: Higher rating indicates better desirability of the property.

More studies on its industrial level production, methods of installation and little other unexplored area related with this material will open its door for construction industry in future.

5. CONCLUSION

Fibre Reinforced Polymer piles and other composite material will be the attractive alternative to the traditional piling materials in coming days and it will be considered in recent years to be a viable alternative to traditional material due to their advantages with respect to their improved service life induced by resistance to corrosion and degradation which steel, timber and concrete piles are vulnerable. Some detailed studies related to its design, drivability, durability are expected to be explored. The use of FRP composite piles as a bearing structure is still under extensive study. Lack of history, specifications and experience on composite materials makes it controversial for considering them as a construction material. The current state of FRP piling is still in its initial stage as there is a gap in knowledge regarding the performance of these material, more studies will open the door of new construction practice.

REFERENCES

[1] Lampo R., Nosker T., Bamo D., Busel J., Maher A., Dutta P., Odello R. (1998), “Development and demonstration of FRP composite fender, load bearing, and sheet piling systems”, USACERL Technical Report, 98/123, Champaign.

[2] Sirmanna C. S. (2011), “Behaviour of fibre composite piles for timber rehabilitation”, University of Southern Queensland, 170.

[3] Ganga Rao, H. and Vijay, P. (2010), “Feasibility review of FRP materials for structural applications”, Report Submitted to (CEERD-CT-T)-US Army Corps of Engineers.

[4] Tomlinson M. J. (1994), “Pile design and construction practices”, Fourth Edition, Taylor & Francis.

[5] Hussein A. S. (2013), “Behaviour of Fibre Reinforced Polymer composite piles- Experimental and Numerical study”, Ph. D. Thesis, 47-52.

[6] Giraldo J., Rayhani M. T. (2014), “Load transfer of hollow Fiber Reinforced Polymer (FRP) piles in soft clay”, Transportation Geotechnics 1, 63-73.

[7] Velez J. D. G. (2013), “Experimental study of hollow Fibre Reinforced Polymer piles in soft clay”, Ph. D. Thesis, 102-104.